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THE MOSQUITO FAUNA OF ROTA ISLAND, MARIANA ISLANDS (DIPTERA: CULICIDAE)[1]

By **Wesley R. Nowell and Donald R. Sutton**[2]

Abstract: A mosquito survey on Rota Island was made during 9–16 May 1976. A variety of natural habitats was sampled and both larval and adult collections were made. A total of 7 species was captured. Three of these were new records for the island and they indicated intra-Mariana Islands distribution. Mosquito-borne diseases and vector species are reviewed for Rota and the other southern Mariana Islands. The collection data are presented and analyzed.

U.S. Navy entomologists made a mosquito survey on the island of Rota in the fall of 1945. A total of 6 species was recovered and 2 of them, *Aedes rotanus* Bohart & Ingram and *Culex litoralis* Bohart, were described as new. According to the literature, this was the only documented survey of the mosquito fauna of Rota.

The data for the October 1945 survey of Rota were included initially by Bohart & Ingram (1946) and in greater detail by Bohart (1957) in their comprehensive reviews of the mosquitoes of the Marianas. These species, with collection information, are listed in the Appendix.

Mosquitoes have been linked with disease transmission in the Marianas. The principal mosquito-borne diseases have been dengue fever, a rather benign type of filariasis, Japanese B encephalitis, and malaria. Only dengue fever has been reported from Rota. However, the occurrence of the other diseases on nearby islands indicates the possibility of local epidemics. There have been several recorded outbreaks of dengue fever in Micronesia and 3 cases were reported from Rota in 1935 (Sogen 1941). An epidemic of dengue fever occurred on the neighboring islands of Tinian, Saipan, and Guam during 1944 (Bohart & Ingram 1946). Filariasis in Guam has been reported (Kindleberger 1912). There was a major epidemic of Japanese B encephalitis on Guam during November 1947–January 1948 (Hammon et al. 1958), and 2 separate outbreaks of malaria occurred on Guam in 1966 and 1969 (Hayes & Whitworth 1970).

Rota is one of the southernmost islands of the Mariana chain, being located about midway between Guam and Saipan. The island is roughly rectangular with a prominent peninsula at its southwest corner. It is 19.8 km at its longest axis, averages 6.3 km in width, and is the highest of the southern Marianas. Gressitt (1954: 53) describes Rota as consisting of a series of 5 or more elevated coral limestone terraces, largely sloping seaward, and rising to 496 m just southwest of the center. The eastern 1/2 is a wide plateau and there are precipitous limestone cliffs along the southern perimeter. The western 1/2 of the island is dominated by Mt Sabana. Gressitt (1954) gives the height of the island as 496 m, but Chart N.O. 81063 (Rota) published by the U.S. Naval Oceanographic Office in Washington, D.C. in June 1969 and revised in 1973 shows a maximum altitude of 491 m. The population center, Songsong Village, is at the west end of the wide bay on the southern coast. Fresh water flows from an artesian source in a cave high up on the southern limestone cliff.

MATERIALS AND METHODS

The island was divided into 7 survey zones, and 1 full day was devoted to sampling mosquitoes in each zone. Collecting methods included the examination of both natural habitats and artificial containers for immature forms, employment of portable light traps, and operation of human bait stations. Particular survey attention was given to the 4 major areas of vector contact or breeding on the island: the airport, Songsong Village, public beaches, and the refuse dump. Totals of 1174 adult and 131 immature mosquitoes were identified. The collection zones and sampling points are shown in FIG. 1, and the zones are described below.

Zone I: This began at Songsong Village and included the narrow western coastline northward to Tatqua Pt. This area is characterized by a narrow beach and littoral on one side and a swath of heavy brush cover to the base of Mt Sabana on the opposite side. This survey area included the refuse dump.

Zones II & III: The eastern end of the island comprised these 2 zones. This relatively level plain measures 5 km north to south and 8 km east to west and has an average elevation of 160 m. It grades gently into the sea along the northern shore but is steep along its southern coastline. The

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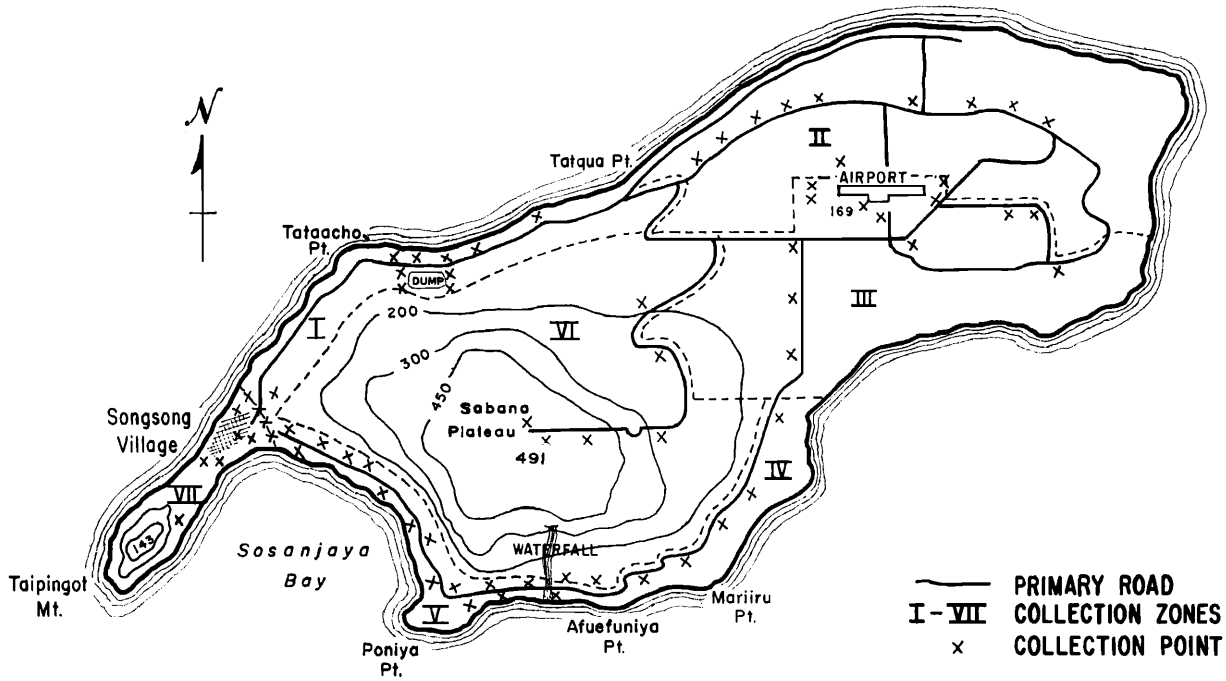

FIG. 1. Mosquito collection locations (larvae and adults) on Rota, Mariana Islands.

plain is overgrown with grass, scrub brush and legume forests with some *Pandanus* jungle. It includes Rota Airfield, the Latte Stone quarry, and ranchland with houses along the northern perimeter. There are no marshes or other stands of water.

Zones IV & V: The southern margin of the island was divided into 2 zones separated by the effluent from the water cave. The narrow, precipitous coastal strip which borders the southeastern base of Mt Sabana was Zone IV. It is heavily overgrown with trees, *Pandanus* thicket and other brush, and high grasses. Zone V began at Songsong Village and bordered the shore of Sosanjaya Bay to Poniya Pt. and terminated within the tropical forest at the water cave stream. Much of this zone had been cultivated and it was quite different from Zone IV in that there were houses on the beach and farms along the base of the mountain.

Zone VI: Mt Sabana constituted Zone VI. This large, stepped, limestone buildup occupies all but the narrow seaside marginal strip of level land of the western 1/2 of Rota. It begins abruptly at sea level and rises in a series of delineated levels or terraces to the 470-m level where it terminates in a flattened plain, Sabana Plateau. An outcropping of volcanic stone at the west end of this plateau marks the highest point of the island. The flora is more varied at the higher levels and there is a small stand of *Acacia* trees on the plateau.

Zone VII: Songsong Village and Taipingot Peninsula on the southwestern corner of the island made up Zone VII. This zone was unique because of its peninsular formation and inclusion of the island's sole population center. The community area extends across the insular end of the peninsula. It consists of small commercial establishments, government buildings, a school, hospital, and private dwellings. Some houses on the northern boundary of the village are interspersed with fields of high grass and brush. There are a variety of artificial containers and the usual catchments associated with roadbeds and graded lots. Remains of the original village dump are still in evidence on the high ground between the comunity and Mt Taipingot at the tip of the peninsula.

RESULTS

The 1976 survey produced a total of 7 species of mosquitoes. Three were new collections records for Rota, and 1 of those is an important vector of dengue fever elsewhere in the Marianas. The collection of *Aedes guamensis* Farner & Bohart, *Ae. rotanus* Bohart & Ingram, *Culex annulirostris marianae* Bohart & Ingram and *Cx. pipiens quinquefasciatus* Say confirmed continued existence of those species captured initially in 1945. The recovery of both adults and immatures of *Cx. pipiens quinquefasciatus* provides the first specific collection records for this species on Rota. The absence of *Aedes aegypti*

(Linnaeus) and *Cx. litoralis* Bohart was expected. While *Ae. aegypti* was prominent during the early surveys in the southern Mariana Islands, the species declined rapidly following massive control programs during the late 1940s. Only a single specimen of this species was discovered on Guam during a 1950 survey, for example, and the species was not recovered there again until 1969 (Reisen et al. 1972). *Cx. litoralis* larvae are found commonly during the rainy season, and they are not found at all during the dry season. According to Bohart (1946), this species is abundant during rainy spells following periods of unusually high tides, the larvae breeding in brackish water of coral rock holes and artificial containers along the shore.

The species collected on Rota for the first time are *Ae. albopictus* (Skuse), *Ae. neopandani* Bohart, and *Ae. pandani* Stone. *Ae. neopandani* has been recorded from Saipan and Tinian; *Ae. pandani* is common on Guam; and *Ae. albopictus* is common on both Guam and Saipan and has also been collected from Tinian. *Ae. albopictus* is a severe pest and it is also considered to be an important vector of dengue fever.

Cx. annulirostris marianae was collected only in the larval form and at a single point along the southeastern coast. *Ae. rotanus* was recovered in great numbers and from each of the 7 collection zones, while only a few (2–7) adults in each of the other 5 species were taken during the entire survey. This disparity in species recovery could have been due to the trapping methods, dates of collection, time of collection, or inability to attract the species. *Ae. albopictus* was collected on the southern coast bordering Sosanjaya Bay, and larvae were taken from artificial containers in Songsong Village. *Ae. pandani* was taken only on the shore of Sosanjaya Bay, while *Ae. neopandani* showed a varied distribution. One adult was collected at Rota Airport, 1 was taken at the 300-m terrace on Mt Sabana, and 2 were trapped on the shore of Sosanjaya Bay. *Ae. guamensis* occurred along the beaches on the northwest and southeast coasts, and larvae of this species were taken from a tree hole near Rota Airport and artificial containers in Songsong Village. This species was consistently collected together with *Ae. rotanus* in both the adult and immature stages. *Cx. pipiens quinquefasciatus* was restricted to Songsong Village and the stream from the water cave.

The specimen totals fluctuated among the 7 collection zones. None of the larval counts was high, except counts in Zone VII (Songsong Village). The greatest number of adults (607) was recorded from Zone V, and the smallest collections were registered for Zones I (35), III (71), and IV (32). *Ae. rotanus* was dominant in numbers of adult and immature specimens collected (1184 out of 1305 identified) and in distribution, since it was recovered from all 7 zones. No immatures and only 35 adults representing *Ae. guamensis* and *Ae. rotanus* were taken in Zone I. This zone included the refuse dump, as well as 2 public beach areas, and there was no apparent reason for the light catch. Zone II yielded 114 adults of *Ae. neopandani* and *Ae. rotanus* and 3 immatures of *Ae. guamensis* with 1 larval *Ae. rotanus* from a tree hole. Since Zone III included Rota Airport, special attention was given to the biological habitats in this zone. However, no immatures were found and only 71 adults (all *Ae. rotanus*) were collected. Immatures (26) of *Cx. annulirostris marianae* and *Cx. pipiens quinquefasciatus* along with 32 adults of *Ae. guamensis* and *Ae. rotanus* were collected in Zone IV. Rain during the early morning along with strong winds off the ocean may have kept the adult populations down. Both species and specimens were most numerous in Zone V; 607 adults of *Ae. albopictus*, *Ae. neopandani*, *Ae. pandani* and *Ae. rotanus*, and 34 larval *Ae. guamensis* and *Ae. rotanus* were collected along this narrow bit of coast. All but 1 of the 169 adults collected in Zone VI were *Ae. rotanus*. Adults were encountered at each terrace level on Mt Sabana, but no immatures were found. A single *Ae. neopandani* was taken at the 300-m level. One hundred forty-six adults of *Ae. rotanus* and *Cx. pipiens quinquefasciatus* were captured on the outskirts of Songsong Village, and 67 larvae of *Ae. albopictus*, *Ae. guamensis* and *Ae. rotanus* were collected from containers within the community area of Zone VII. Constant wind and rain during the night inhibited capture of adults in the lower peninsula.

This survey was performed at the end of a sustained dry period, so mosquito breeding was probably minimal. The survey might have been more productive if it could have been conducted at another time, but because it was in support of a pending Air Force tactical hospital deployment to Rota, it had to be accomplished early in May. The only ground pools noted were those resulting from leaks in the pipes conveying water from the water cave to the airport, Songsong Village, and the farms and homes on the northeastern and southwestern coasts. Because of lack of rain, most of the numerous artificial containers were empty. These included beverage cans, coconut shells, and land snail shells. The water levels in the discarded tires, cisterns and metal drums were generally low. Some *Pandanus* and taro leaf axils contained water,

TABLE 1. Mosquito collection data, Rota Island, May 1976.

SPECIES	COLLECTION ZONE*	No. SPECIMENS	LOCALITY DATA	ASSOCIATED SPECIES
Aedes albopictus (Skuse)**	V	1 adult	Coast of Sosanjaya Bay, at human bait station	*Ae. rotanus*
	V	1 adult	E of Poniya Pt., at human bait station	*Ae. rotanus*
	V	1 adult	At water cave stream, in light trap	None
	VII	45 larvae	In Songsong Village, in artificial containers (metal drum, pottery crock, tire, watering basin)	Larvae of *Ae. guamensis* and *Ae. rotanus*
Aedes guamensis Farner & Bohart	I	1 adult	Beach near Tataacho Pt., in light trap	*Ae. rotanus*
	I	1 adult	McKay's Beach, at human bait station	None
	II	3 larvae	W end of Rota Airport, in *Acacia* tree hole	Larva of *Ae. rotanus*
	IV	2 adults	At water cave stream, in light trap	None
	IV	1 adult	Near Afuefuniya Pt., in light trap	*Ae. rotanus*
	IV	1 adult	At Mariiru Pt., in light trap	*Ae. rotanus*
	V	4 larvae	At Poniya Pt., in clay pot	Larvae of *Ae. rotanus*
	VII	21 larvae	In Songsong Village, in artificial containers (metal drum, pottery crock, tire, watering basin)	Larvae of *Ae. albopictus* and *Ae. rotanus*
Aedes neopandani Bohart**	II	1 adult	N of Rota Airport, in light trap	*Ae. rotanus*
	V	1 adult	Coast of Sosanjaya Bay, near Poniya Pt., at human bait station	*Ae. rotanus*
	V	1 adult	Coast of Sosanjaya Bay, in light trap	*Ae. rotanus*
	VI	1 adult	On Mt Sabana (300-m terrace), in light trap	*Ae. rotanus*
Aedes pandani Stone**	V	2 adults	Coast of Sosanjaya Bay, near Poniya Pt., in light trap	*Ae. rotanus*
Aedes rotanus Bohart & Ingram	I	33 adults	At refuse dump and on beach near Tataacho Pt., in 10 light traps. At Tataacho Pt., McKay's Beach, and Tatqua Pt., at human bait stations	None
	II	94 adults	Along the north road, in 10 light traps spaced 0.8–1.6 km apart	*Ae. neopandani*
	II	3 adults	In *Pandanus* thicket 0.4 km N of Rota Airport, at human bait station	None
	II	16 adults	By ironwood trees 0.4 km E of Rota Airport, at human bait station	None
	II	1 larva	W end of Rota Airport, in *Acacia* tree hole	Larvae of *Ae. guamensis*
	III	3 adults	At Japanese Cemetery, at human bait station	None
	III	68 adults	Along road from Japanese Cemetery N to airport and E to Latte Stone Quarry, in 8 light traps spaced 1.6 km apart	None
	IV	28 adults	Along coastal road, in 7 light traps spaced 0.8 km apart	*Ae. guamensis*
	V	33 adults	Along coastal road, at 4 human bait stations spaced 1.6 km apart	*Ae. albopictus* and *Ae. neopandani*
	V	567 adults	Along coastal road, in 8 light traps spaced 0.8 km apart	*Ae. pandani*
	V	30 larvae	At Poniya Pt., in clay pot	Larvae of *Ae. guamensis*
	VI	12 adults	In *Acacia* grove on Sabana Plateau (480 m), at human bait station	None
	VI	11 adults	On Sabana Plateau (475 m), at human bait station	None
	VI	14 adults	On Mt Sabana (400-m terrace), at human bait station	None
	VI	14 adults	On Mt Sabana (350-m terrace), at human bait station	None
	VI	54 adults	On Mt Sabana (300-m terrace), in light trap	*Ae. neopandani*
	VI	63 adults	On Mt Sabana (200-m terrace), in light trap	None

Table 1 (continued)

	VII	121 adults	At N end Songsong Village at base of Mt Sabana, in light trap	None
	VII	18 adults	Along northern perimeter of Songsong Village, in 4 light traps	None
	VII	2 adults	At southern end of Songsong Village, in light trap	None
	VII	1 larva	At domicile at N end of Songsong Village, in crock	None
Culex annulirostris marianae Bohart & Ingram	IV	21 larvae	By water cave stream, in a tire used as watering trough in a hog pen	Larvae of *Cx. pipiens quinquefasciatus*
Culex pipiens quinquefasciatus Say	IV	5 larvae	By water cave stream, in a tire used as watering trough in a hog pen	Larvae of *Cx. annulirostris marianae*
	VII	7 adults	In Songsong Village, in a metal drum	None

*See text for explanation of zones.
**New records for Rota Island.

but the majority of the tree holes sampled were dry. The survey data are shown in TABLE 1.

DISCUSSION

The significance of these 1976 collection data is twofold: there is interisland introduction of mosquito species to Rota, and a change has occurred in the disease potential on Rota. The island was being serviced by 2 commercial airlines and a total of 5 flights per day were landing at Rota Airport. Three of the flights originated at Guam, while the remaining 2 were return stops from Saipan. There was no evidence of aircraft disinsection procedures on the interisland flights, and no mosquito control activities were conducted at the Rota Airport. There is considerable likelihood that the daily flights from Guam and Saipan will provide additional introductions of mosquitoes into Rota unless controls are established. Collection records on Guam, for instance, showed that when nondisinsected flights continued over a sustained period there was a substantial increase in the species count (Nowell 1977). It would appear that *Ae. neopandani* has already been introduced from Saipan, *Ae. pandani* has been introduced from Guam, and that *Ae. albopictus* could have come from either Guam or Saipan. These are classic examples of interisland importation. The introduction of *Ae. albopictus* has brought an acknowledged vector of dengue fever to the island. This is potentially dangerous with the concentration of the island's population in Songsong Village, because the arrival of a single individual infected with the dengue fever virus could trigger an epidemic of dengue fever on Rota.

This survey confirms the presence of 4 species known from the earliest recorded collections on Rota, and it indicates intra-Marianas introduction of 3 additional species from Guam and Saipan. It shows an increase in island vector capability. It also reveals the lack of disinsection procedures by air carriers and the absence of a mosquito control program at Rota Airport. A total of 9 species in the genera *Aedes* and *Culex* now have been recorded from Rota. They are as follows: *Aedes* (*Stegomyia*) *aegypti* (Linnaeus), *Ae.* (*Stg.*) *albopictus* (Skuse) (new record), *Ae.* (*Stg.*) *guamensis* Farner & Bohart, *Ae.* (*Stg.*) *neopandani* Bohart (new record), *Ae.* (*Stg.*) *pandani* Stone (new record), *Ae.* (*Stg.*) *rotanus* Bohart & Ingram (type-locality), *Culex* (*Culex*) *annulirostris marianae* Bohart & Ingram, *Cx.* (*Cux.*) *litoralis* Bohart (type-locality), and *Cx.* (*Cux.*) *pipiens quinquefasciatus* Say.

Acknowledgments: All specimens were identified by Mrs Adela Cagampang-Ramos, and those adults determined by her as *Ae. pandani* Stone or *Ae. neopandani* Bohart were sent to the Medical Entomology Project, Smithsonian Institution, Washington, D.C., for confirmation. The above specimens and others collected during May 1976 on Rota Island are deposited in the Bernice P. Bishop Museum, Hawaii. We express our appreciation to Mrs Cagampang-Ramos, Vector Taxonomy Section, 1st Medical Service Wing, for her assistance; Dr Ronald A. Ward, Project Manager, Medical Entomology Project, for reviewing the *Ae. pandani* and *Ae. neopandani* specimens; and Miss Francia C. Butiu for typing the final manuscript.

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APPENDIX

Mosquito collection records for Rota Island, 1945 (Bohart & Ingram 1946, Bohart 1957)

Aedes (Stegomyia) aegypti (Linnaeus)

1 ♀ collected from an artificial container at Port of Sonson (or Sanrago) [Songsong Village?] by R. Bohart & R. Ingram during October 1945. According to Bohart (1957), "this species was abundant on Guam in 1945 but after an intensive control campaign it became difficult to find there and on Tinian, and no recent records are available for Rota and Saipan."

Aedes (Stegomyia) guamensis Farner & Bohart

21 ♂♂, 20 ♀♀, and 2 pupal skins taken in tree holes in October 1945 by R. Bohart & R. Ingram.

Aedes (Stegomyia) rotanus Bohart & Ingram

44 ♂♂, 36 ♀♀, 23 pupal skins and 50 larvae collected on the north side of Rota (type-locality) on 26 October 1945. Larvae were found commonly in *Pandanus* leaf axils; less frequently in tree holes and artificial containers. Reared by R. Bohart & R. Ingram in 1945; collected by R. Bohart in June 1951.

Culex (Culex) annulirostris marianae Bohart & Ingram

1 ♀ collected in Sonson (Songsong Village?) by W. L. Necker, October 1945; 1 ♂, 5 ♀♀, and 1 larva from a cistern and stream pool at Poniya Pt., by R. Bohart & R. Ingram in October 1945. According to Bohart & Ingram (1946), larvae were found in concrete cisterns near houses and in agricultural fields.

Culex (Culex) litoralis Bohart

2 ♂♂, 1 ♀, 1 pupal skin, and 19 larvae collected from coral rock holes on the northeast coast of Rota (type-locality) by R. Bohart & R. Ingram on 26 October 1945. Reared from brackish coral rock hole by R. Bohart & R. Ingram.

Culex (Culex) pipiens quinquefasciatus Say

No specific collection data, but recovery of this species on Rota was indicated by Bohart & Ingram (1946) and Bohart (1957).